Measurement of Electromagnetic Signal Strengths of Four GSM Base Stations at 900 MHz in a Pilot Region

S. S. Durduran[1], *L. Seyfi[2], C.Avcı[3] and A. M. Ozan[4]

***Abstract*—Mobile phones are used by a wide range of people. Even children use mobile phone although they are in high risk group. Because of this, use of mobile phone should be evaluated based on valid and safe information and measurements. We can utilize mobile phone in a way we desire, that is, we can turn it off in order to avoid its radiation when we do not want to use it. However, we cannot control base stations; moreover we do not know where they are mounted. So, radiation of base stations has more importance than that of mobile phones in this respect. Additionally, some GSM service providers may prefer to conceal base station in a way people cannot notice when people are probably opposed to mounting of base station very close to their live space.**

In this paper, signal strength of base stations (900 MHz) in a pilot region were measured and recorded. The selected region was averagely 500,000 m2 and has 4 base stations. 53 measurement points were determined on the streets of the region. The measurement region had nearly 97 apartments and these apartments had between 400 and 500 flats. The population living in this region was between 1500 and 2000.

The averaged signal strength over 53 points in this pilot region were estimated as − 72.7 dBm. The minimum and maximum measurements were recorded as −87 and − 47 dBm, respectively. The standard deviation of the measurement values was calculated as − 8.5 dBm.

***Index Terms*— Base stations, electromagnetic waves, health effects, mobile phones, radiation,**

I. Introduction

MOBILE phones were started to be widely utilized in 1990s all over the world [1] Since the beginning utilization of them has rapidly risen. More and more people use them day by day. Because of the augmenting number of mobile phone users, the number of base stations, which enable mobile phones to connect to other mobile phones, are to be increased to provide a well communication chance [2]. Therefore, base stations are to be mounted closer to each other [3]. Moreover, the widespread use of 3G needs new and more base stations than 2G system [4].

Thus, base stations can be shown every region we live and electromagnetic waves always exposes us everywhere in modern society [5].

Although some people are against, it must be accepted that telecommunications are vital in today's world [5]. In most countries, possible detrimental effects of radiation of mobile phones and base stations worried public due to extremely using of them [4]- [6]. Additionally, it is considered that they have more risk for especially children [3].

Frequency of Electromagnetic fields used for telecommunications is in the non-ionizing radiation part in the electromagnetic spectrum [6].

When the full capacity of a base station is reached, that is when the number of calling people over the base station is maximum, the radiation of it is to be maximum [6]. A mobile phone starts a call sending RF (radio frequency) signals to the nearest base station. If the called number is a mobile phone, the call is routed to another base station which is the closest to called mobile phone. When finished the call, the mobile phone gets into idle position in which it merely sends data to the base station at regular intervals [3].

The mean power transmitted by a mobile phone is reduced due to adaptive power control. Adaptive power control adjusts the mobile phone output power which provides enough signal strength to the base station. Thus, the level of signal strength from a mobile phone is not always same. It has the highest value during initiating a call. In this position, the mobile phone controls all the channels to prefer the best signal for the best connection [3]. A radiation measurement in terms of electric field (V/m) of a typical mobile phone call is shown in Fig.1. It should be noted that the radiation value of a mobile phone while calling vary depending on the distance to base station. That is, it is higher when the base station is farther.

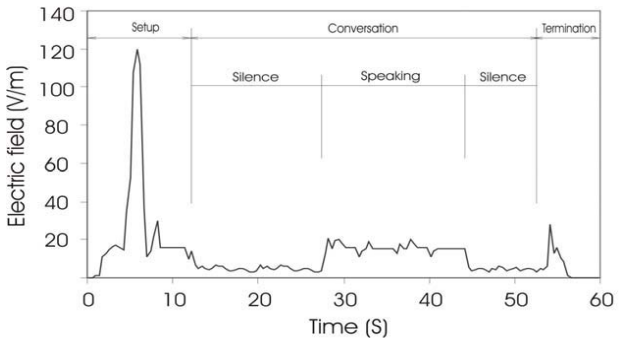

Fig. 1. Electric field values emitted from a typical GSM phone while making a call [3].

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As the radiation level of a mobile phone during a call is higher than that of a base station [5],[7],[8] and the mobile phone is very close to user's head, mobile phones get more attention from scientists [4]. However, this may not be known by the general public. Further, it should be noted that the radiation of base stations expose people 24h a day [5]. This situation is more important for living in close neighbourhood to a base station.

Considering all these reasons, in this work, signal strengths of base stations working at 900 MHz in a pilot region were measured and recorded. In Turkey, 3 GSM companies (Turkcell, Vodafone, and Avea) provide service to mobile phone users. The measurement region was averagely 500,000 m^2 and had 4 base stations. 53 measurement points were determined on the streets of the region. The number of related apartments in the measurement region was nearly 97 and the number of flats was between 400 and 500. The population living in this region was between 1500 and 2000.

II. Health Effects

It is definitely fixed that very high level electromagnetic fields can cause considerable health effects, such as burns, but exposure limits determined by some organizations prevent them from such effects. Actual concerns are focused on long-term exposure to weak fields [5].

These concerns especially originated from mobile phones and base stations have arisen for a long time. There are some studies relating them with brain tumors or accelerate the growth of subclinical tumors [9] - [13]. Moreover, some studies associate them with some health problems containing birth defects, brain tumors, lymphomas, and memory problems [3], [14] - [21].

Because base stations are sometimes mounted within meters of our living places such as home and school, it adversely affects public. A reason for rising concern of public about mobile phones and base stations is that Whether base station radiation can modify biology of our body is still uncertain due to some study limitations and undetermined results [22]- [29]. Even the risk is small for our health; the total effect will be dreadful due to the very high number of exposed people [30]-[31].

In respect of consequences, mobile phones and base stations are technologies non-identified [32],[33]. Especially mysterious or possible catastrophic consequences might be shown to comprehend the risk [4], [34] -[36].

The supposition that exposure to electromagnetic waves might produce health damage has been studied in several epidemiological works [14]-[21]. Especially leukemia in children and brain tumors were the clinical entities frequently encountered. Up to now, these works have not shown reliable enough results to assess human cancer risk from exposure to electromagnetic waves because the results of these works were conflicting. This situation may be elucidated by variation of the design, execution of these works and different commentary of the results [3]. Therefore, Non-ionizing electromagnetic radiation including mobile phone and base station radiation is believed to be harmless at very low intensities, although it can be damaging at high intensities [3], [37]. Additionally there is no strong supporting document that the risks are higher among persons who used mobile phones for 60 or more minutes per day or regularly for five or more years. But they are not adequate in order to assess the risks among long-term, heavy users and for potentially long induction periods [1].

The organizations determining national or international limits of exposure to radio frequency are the World Health Organization (WHO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Federal Communication Commission (FCC), the International Radiation Protection Association (IRPA), and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)

The exposure limits, even international, is not universally adopted. For instance, the limit is 4 W/m^2 in UK, 2 W/m^2 in Australia, 0.042 W/m^2 in Switzerland, 0.1 W/m^2 in Italy and 4.5W/m^2 in Turkey [3,38].

III. Measurement Results

In this study, electromagnetic field strengths of 4 base stations in a pilot region were observed. Vodafone and Turkcell works at 900 MHz in Turkey. The pilot region was averagely 500,000 m^2 and had 4 base stations. 53 measurement points were determined on the streets of the region as shown in Fig. 2. The number of apartments in the pilot region was nearly 97 and the number of flats was between 400 and 500. The population living in this region was between 1500 and 2000.

Power density values of the pre-determined locations were measured and recorded in dBm. The measured values with respect to location data (obtained by a GPS) are shown in appendix. The minimum and maximum measurements were recorded as −87 dBm (0.1nW/m^2) and − 47 (757.9 nW/m^2) dBm, respectively. The averaged signal strength over 53 points in this pilot region were estimated as − 72.7 dBm (25.9 nW/m^2). The standard deviation of the measurement values was calculated as − 8.5 dBm. It was around 12 % of the mean value of all measurements.

Measurements were carried out with Spectran HF 6080 spectrum analyzer. Measurement values were recorded in dBm. The dBm values were converted to W/m^2 with the following formula given in the manual of spectrum analyzer.

$$S = \frac{10^{\left(\frac{p-G}{10}\right)}}{1000} * \frac{4*\pi}{\lambda^2} \quad (1)$$

Here, p is the measured power (dBm), λ is the wavelength of the transmitter frequency (m), and G the antenna gain (dBi).

Downlink frequency of base station at 900 MHz is assumed as 950 MHz and G is determined as 5.2 dBi for 950 MHz in the manual. λ is calculated for this frequency $c/f = 3x10^8/(950x10^6) = 0.316m$

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Fig. 2. The distribution of measurement points on the pilot region

IV. Conclusion

It was observed that the selected region was crowded the measurement results were measured low (in order of nW/m^2) and found well below the exposure limit recommended by the international health organizations. Some measurement values were observed very higher than the others. That is, it can be said that the electromagnetic field strength value can considerably vary with respect to location.

Appendix: Measurement Data

Meas. Number	Signal Strength (dBm)	Signal Strength (nW/m^2)	Coordinates
1	-70	3,8	32.49159,37.91442,-1066
2	-76	1,0	32.49159,37.91438,-1066
3	-76	1,0	32.49153,37.91431,-1065
4	-53	190,4	32.49152,37.91426,-1125
5	-76	1,0	32.49144,37.91415,-1068
6	-54	151,2	32.4912,37.91425,-1075
7	-84	0,2	32.49115,37.91432,-1070
8	-59	47,8	32.49105,37.91434,-1098
9	-47	757,9	32.49085,37.91443,-1063
10	-64	15,1	32.49089,37.9142,-1100
11	-71	3,0	32.4913,37.91392,-1071
12	-73	1,9	32.49049,37.91397,-1073
13	-66	9,5	32.48986,37.91418,-1069
14	-60	38,0	32.48952,37.9143,-1070
15	-83	0,2	32.4888,37.91405,-1072
16	-79	0,5	32.48932,37.91391,-1073
18	-77	0,8	32.4898,37.91379,-1060
19	-77	0,8	32.49008,37.91371,-1063
20	-69	4,8	32.49027,37.91364,-1064
21	-69	4,8	32.49059,37.91345,-1064
22	-66	9,5	32.49082,37.91337,-1066
23	-80	0,4	32.49111,37.91364,-1071
24	-66	9,5	32.49098,37.91342,-1070
25	-61	30,2	32.49081,37.91316,-1070
26	-78	0,6	32.49035,37.91265,-1071
27	-83	0,2	32.49,37.9128,-1066
28	-87	0,1	32.48984,37.91286,-1064
29	-81	0,3	32.4897,37.91297,-1064
30	-81	0,3	32.48891,37.91323,-1068
31	-75	1,2	32.48842,37.91339,-1071
32	-75	1,2	32.48809,37.91315,-1072
33	-84	0,2	32.48804,37.91305,-1073
34	-85	0,1	32.48806,37.913,-1076
35	-79	0,5	32.48836,37.91287,-1073
36	-79	0,5	32.48864,37.91272,-1071
37	-76	1,0	32.48912,37.91248,-1070
38	-74	1,5	32.48976,37.91219,-1070
39	-74	1,5	32.48994,37.9121,-1071
40	-64	15,1	32.4894,37.91185,-1076
41	-70	3,8	32.48901,37.91199,-1072
42	-71	3,0	32.48859,37.91214,-1077
43	-71	3,0	32.48823,37.91232,-1075
44	-77	0,8	32.488,37.91247,-1073
45	-77	0,8	32.48753,37.91269,-1073
46	-75	1,2	32.48712,37.91222,-1074
47	-69	4,8	32.48726,37.91213,-1071
48	-75	1,2	32.48764,37.91193,-1068
49	-75	1,2	32.488,37.91179,-1070
50	-75	1,2	32.48817,37.91172,-1068
51	-74	1,5	32.48853,37.91157,-1070
52	-81	0,3	32.48862,37.91146,-1070
53	-71	3,0	32.48836,37.91126,-1072
54	-60	38,0	32.48826,37.91132,-1068

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